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Professional Science Knowledge and its Impact on Confidence in the Teaching of Earth Science

A thesis presented in partial fulfilment of the requirements for the degree of Master of
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By
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ABSTRACT

This study focused on the nature and parameters of the relationships between the professional science knowledge of primary and intermediate teachers and their confidence in teaching in the *Making Sense of Planet Earth and Beyond* strand of *Science in the New Zealand Curriculum* (earth science). The study was divided into two phases of data collection. The first phase used a questionnaire survey of 18 teachers from the Taranaki, Wanganui, Manawatu, Palmerston North and Horowhenua districts of the western and central North Island of New Zealand. The survey identified the influence of the relationships between the participants' backgrounds in earth science, their professional knowledge frameworks and their efficacy to teach earth science. The second phase of data collection builds on the trends and common themes identified in phase one. Data were collected in the second phase through interviews of four teachers selected from phase one participants.

Analyses of the data collected revealed the importance of maintaining a well-developed understanding of the subject matter when teaching earth science. Subject matter knowledge has a notable impact in teachers' efficacy beliefs and ability to translate content into teachable material. Findings support previous researchers' conclusion that teachers with high self-efficacy have had a long interest in science and a relatively strong background of formal science studies with opportunities for exploring science in informal settings. Results indicate that effective earth science teachers possess a genuine interest and enthusiasm for earth science. Conversely, teachers with relatively little earth science background display less developed knowledge frameworks and weaker efficacy beliefs. Common indicators of these weaknesses include avoidance of earth science topics in general or use of 'shallow' teaching strategies such as transmission approaches or 'resource based' units. In some cases it appears that teachers' confidence in their ability to teach earth science may be misplaced. Results indicate that in some cases, teachers can use their considerable classroom skills to avoid confronting earth science concepts where their knowledge is inadequate. The implications for these findings are considered.

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TABLE OF CONTENTS

ABSTRACT	(ii)
ACKNOWLEDGEMENTS	(iii)
TABLE OF CONTENTS	(iv)
LIST OF TABLES	(x)
LIST OF FIGURES	(xii)
CHAPTER 1: INTRODUCTION	1
1.1 Background to the study	2
1.2 Rationale for the Study	3
1.3 Significance of the Study	4
1.4 Outline of the Thesis	5
CHAPTER 2: REVIEW OF LITERATURE	7
2.1 Science Education in New Zealand	7
2.1.1 Introduction	7
2.1.2 A History of Science Education In New Zealand	8
2.1.2.1 Early Science Education	8
2.1.2.2 Nature Study	9
2.1.2.3 The Curriculum Review	10
2.1.2.4 The Draft Syllabus	11
2.1.3 Science in the New Zealand Curriculum	12
2.1.3.1 The Structure of the Curriculum Document	12
2.1.3.2 Problems of Balance and Coherence	14
2.1.4 The Making Sense of Planet Earth and Beyond Strand	17
2.1.4.1 History of Earth Science Education in New Zealand	17
2.1.4.2 The Structure of the Strand	19
2.1.4.3 The Status of Earth Science Education in New Zealand	20
2.1.4.4 The Delivery of making Sense of Planet Earth and Beyond	21
2.1.5 Summary	22

2.2	Self-Efficacy	24
2.2.1	Introduction	24
2.2.2	Self-Efficacy Defined	24
2.2.2.1	Rotter's Locus of Control	25
2.2.2.2	Outcome Expectancy	26
2.2.3	Self-Efficacy Dimensions	26
2.2.4	Effects of Self-Efficacy	27
2.2.5	Sources of Self-Efficacy	29
2.2.5.1	Enactive Mastery Experiences	29
2.2.5.2	Vicarious Experiences	29
2.2.5.3	Verbal Persuasion	30
2.2.5.4	Physiological and Affective States	30
2.2.6	Gender Differences	31
2.2.7	Teacher Efficacy	32
2.2.7.1	The Teacher Efficacy Construct	33
2.2.8	Applications in the Teaching of Earth Science	34
2.2.9	Summary	35
2.3	Professional Science Knowledge	36
2.3.1	Introduction	36
2.3.2	Knowledge and Science Teaching	36
2.3.3	Types of Professional Knowledge	38
2.3.4	The Sources of Professional Science Knowledge	39
2.3.5	Subject Matter and Content Knowledge	40
2.3.5.1	Knowledge of Facts and Concepts	40
2.3.5.2	Substantive and Syntactic Structures	42
2.3.6	Pedagogical Content Knowledge	44
2.3.7	General Pedagogical Knowledge	46
2.3.8	Curricular Knowledge	47
2.3.9	Summary	47

2.4	Research Hypotheses	48
2.4.1	Hypothesis One	48
2.4.2	Hypothesis Two	49
2.4.3	Hypothesis Three	49
2.4.4	Hypothesis Four	50
CHAPTER 3:	METHODOLOGY	51
3.1	Introduction	51
3.2	Theoretical Framework	51
3.3	The Research Procedure	53
3.4	Phase One: The Teacher Survey	53
3.4.1	Participants	53
3.4.2	Consent	53
3.4.3	Coding and Confidentiality	54
3.4.4	Administering the Questionnaires	54
3.5	The Teacher Survey Tasks	54
3.5.1	Section One: Background information	55
3.5.2	Section Two: Teacher Knowledge Perceptions	55
3.5.3	Section Three: Teacher Efficacy Perceptions	56
3.5.4	Processing Survey Results	58
3.6	Phase Two: Teacher Interviews	58
3.6.1	Participants	58
3.6.2	Consent	59
3.6.3	Coding and Confidentiality	59
3.6.4	Administering the Interviews	59
3.7	The Interview Tasks	60
3.7.1	Processing Interview Results	61
3.8	Summary	61
CHAPTER 4:	PHASE ONE RESULTS	62
4.1	Introduction	62
4.2	Response to Phase One	62
4.3	Process	64
4.4	Teachers' Backgrounds	64

4.4.1	Background and Efficacy Belief	65
4.4.2	Efficacy, Knowledge and Background in Science	67
4.4.3	Gender Differences	70
4.4.4	Class Size and Student Age Group	71
4.4.5	Teaching Experience	72
4.5	Teachers' Perceptions of their Professional Science Knowledge	74
4.5.1	Perceptions of Strand Difficulty	75
4.5.2	Perceptions of <i>Making Sense of Planet Earth</i> and <i>Beyond</i> theme difficulty	76
4.6	Knowledge in Teaching Earth Science	78
4.6.1	The Composition of Planet Earth	79
4.6.2	The Processes That Shape Planet Earth	80
4.6.3	New Zealand's Geological History	81
4.6.4	The Movement of Planet Earth in Relationship to Other Objects in the Heavens	82
4.6.5	The Need for Responsible Guardianship of the Planet and its Resources	83
4.7	Relationships Between Knowledge Dimensions	85
4.7.1	Relationships Between Knowledge Dimensions and Teachers' Backgrounds	91
4.8	Efficacy in Teaching Earth Science	92
4.8.1	Scenario One: The Composition of Planet Earth	93
4.8.2	Scenario Two: The Processes That Shape Planet Earth	95
4.8.3	Scenario Three: New Zealand's Geological History	96
4.8.4	Scenario Four: The Movement of Planet Earth in Relationship to Other Objects in the Heavens	97
4.8.5	Scenario Five: The Need for Responsible Guardianship of The Planet and its Resources	98
4.9	Teachers' Efficacy Beliefs	99
4.10	Knowledge and Efficacy	102
4.11	Summary	108
CHAPTER 5: PHASE TWO RESULTS		112
5.1	Introduction	112
5.2	Response to Phase Two	112
5.3	Process	113
5.4	The Influence of Teachers' Background on Knowledge and Self-Efficacy	114

5.5	Teachers' Knowledge Structures	116
5.5.1	Subject Matter Knowledge	117
5.5.2	Pedagogical Content Knowledge	119
5.5.3	General Pedagogical Knowledge and Curricular Knowledge	123
5.6	Teachers' Efficacy Beliefs	124
5.6.1	Choice or Avoidance of Earth Science Topics	125
5.6.2	The Influence of interest and Enthusiasm	126
5.6.3	Effort Expenditure and Persistence	127
5.6	Other Factors Affecting Participants' Delivery of Earth Science	128
5.7	Summary	129
CHAPTER 6: DISCUSSION		131
6.1	Introduction	131
6.2	The Influence of Professional Science Knowledge on Strength of Efficacy Belief	132
6.2.1	Subject Matter Knowledge and Efficacy Belief	133
6.2.2	General Pedagogical Knowledge and Efficacy Belief	135
6.2.3	Pedagogical Content Knowledge and Efficacy Belief	137
6.3	The Influence of Background on Professional Science Knowledge	139
6.3.1	Background Experiences that Contribute to Professional Science Knowledge	143
6.3.2	The Role of Interest and Enthusiasm	145
CHAPTER 7: CONCLUSIONS		147
7.1	Introduction	147
7.2	Review of the Study	147
7.3	Major Findings of the Study	149
7.4	Limitations of the Study	151
7.5	Recommendations for further Research	153
7.6	The Significance of the Study	153
7.7	Summary	154

APPENDICIES	
Appendix A: Letters	156
Appendix B: The Teacher Survey	160
Appendix C: Teacher Interview interviews	173
BIBLIOGRAPHY	177

LIST OF TABLES

Table 1	Perceived competence of primary, kura kaupapa and intermediate teachers in teaching concepts of <i>Making Sense of Planet Earth and Beyond</i> .	19
Table 2	Comparison of teachers' background in science with knowledge-efficacy categories.	68
Table 3	Difficulty of the strands of <i>Science in the New Zealand Curriculum</i> , as perceived by primary and intermediate teachers.	75
Table 4	Teachers' perceptions of efficacy in teaching the themes within the <i>Making Sense of Planet Earth and Beyond</i> strand.	76
Table 5	Teachers' Perceptions of their knowledge in the teaching of <i>Making Sense of Planet Earth and Beyond</i> .	78
Table 6	Teachers' perceptions of their knowledge in the teaching of the composition of planet Earth.	79
Table 7	Teachers' perceptions of their knowledge in the teaching of the processes that shape planet Earth.	80
Table 8	Teachers' perceptions of their knowledge in the teaching of New Zealand's geological history.	81
Table 9	Teachers' perceptions of their knowledge in the teaching of the movement of planet Earth in relationship to other objects in the heavens.	82
Table 10	Teachers' perceptions of their knowledge in the teaching of the need for responsible guardianship of the planet and it's resources.	83
Table 11	Comparison of teachers' background in science with knowledge scores.	91
Table 12	Teacher's perceptions of their efficacy in teaching in the <i>Making Sense of Planet Earth and Beyond</i> strand.	92
Table 13	Teacher's perceptions of their efficacy in teaching a topic based on the composition of planet Earth.	94
Table 14	Teacher's perceptions of their efficacy in teaching a topic based on the processes that shape planet Earth.	95

Table 15	Teacher’s perceptions of their efficacy in teaching a topic based on New Zealand’s geological history.	96
Table 16	Teacher’s perceptions of their efficacy in teaching a topic based on the movement of planet Earth in relationship to other objects in the heavens.	97
Table 17	Teacher’s perceptions of their efficacy in teaching a topic based on the need for responsible guardianship of the planet and its resources.	98

LIST OF FIGURES

<i>Figure 1</i>	Participants' formal background in science.	66
<i>Figure 2</i>	Comparison by gender of perceptions of knowledge and efficacy in the teaching of the <i>Making Sense of Planet Earth and Beyond</i> strand.	71
<i>Figure 3</i>	Comparison of class size with teachers' efficacy Scores.	72
<i>Figure 4</i>	Comparison of class year group with teachers' efficacy scores.	72
<i>Figure 5</i>	Comparison of teachers' experience and perceived knowledge scores.	73
<i>Figure 6</i>	Comparison of teachers' experience and efficacy scores.	74
<i>Figure 7</i>	Comparison of participants' subject matter knowledge with pedagogical content knowledge.	85
<i>Figure 8</i>	Comparison of participants' pedagogical content knowledge with general pedagogical knowledge.	86
<i>Figure 9</i>	Comparison of participants' subject matter knowledge with general pedagogical knowledge.	87
<i>Figure 10</i>	Comparison of participants' curricular knowledge with subject matter knowledge.	88
<i>Figure 11</i>	Comparison of participants' curricular knowledge with pedagogical content knowledge.	89
<i>Figure 12</i>	Comparison of participants' curricular knowledge with general pedagogical knowledge.	90
<i>Figure 13</i>	Comparison of teachers' choice and enjoyment scores.	99
<i>Figure 14</i>	Comparison of teachers' persistence and effort scores.	100
<i>Figure 15</i>	Comparison of teachers' enjoyment/choice and effort/persistence scores.	102
<i>Figure 16</i>	Comparison of teachers' overall knowledge and efficacy levels.	103
<i>Figure 17</i>	Comparison of teachers' subject matter knowledge and efficacy levels.	104

<i>Figure 18</i>	Comparison of teachers' pedagogical content knowledge and efficacy levels.	105
<i>Figure 19</i>	Comparison of teachers' general pedagogical knowledge and efficacy levels.	105
<i>Figure 20</i>	Comparison of teachers' curricular knowledge and efficacy levels.	106

CHAPTER 1

INTRODUCTION

The study described in this thesis made an examination of the influences of primary and intermediate teachers' professional science knowledge frameworks on their confidence to teach earth science. The overall aim of this study is to investigate whether the knowledge teachers possess about earth science concepts and the teaching of earth science¹ has any influence on their feelings of efficacy in teaching earth science.

The current 'best practice' in science teaching is generally regarded as the use of constructivist teaching approaches with an emphasis on fostering students' conceptual development (Skamp, 1997). Such approaches place a great demand on teachers' professional knowledge frameworks. Also, the use of these techniques requires a high level of belief that one can do so effectively.

Personal experiences, informal observations and anecdotal evidence suggest that in an effort to teach constructively, primary and intermediate teachers, often resort to watering down the content of science programmes. Such an occurrence is tragic from the science educator's perspective, but it is also understandable. Many primary and intermediate teachers are not science specialists and possess neither the knowledge, the confidence or the inclination to teach earth science when they would be far more comfortable teaching other subjects (Tilgner, 1990). Of these personal attributes, teachers' confidence has received the greatest amount of research attention.

Pre-service teacher education programmes generally address this lack of confidence by providing positive teaching experiences. However, in the personal experiences of the author these experiences rarely address earth science topics and often take place in artificial contexts that may actually trivialise the efficacy-building potential of these

¹ For the purpose of this study, all material associated with the *Making Sense of Planet Earth and Beyond* strand of *Science in the New Zealand Curriculum* will be referred to as Earth science.

experiences. It is the author's belief that by bringing meaningful content back into primary science, and providing teachers with this content, or the means to access it, teachers will have more confidence to teach earth science effectively.

Background to the Study

Teacher confidence and competence in teaching science has long been an issue in New Zealand. After the first review of the implementation of *Science in the New Zealand Curriculum*, a report from the Education Review Office (1996) noted that many schools were identified as not covering all four of the contextual strands and the two integrating strands. The report also identified a tendency for primary schools to place greater emphasis on the contextual strand *Making Sense of the Living World*, while other strands, especially *Making Sense of the Physical World* and *Making Sense of the Material World* received much less attention.

"Expertise in teaching science" (Education Review Office, 1996, p. 22) and teacher confidence were reported to be "the most significant barriers to the successful implementation of *Science in the New Zealand Curriculum*" (ibid). Teachers cite "lack of knowledge, confidence and support" as a major factor.

The findings of the *Third International Mathematics and Science Study* (TIMSS) in 1994 revealed a disturbingly low level of science achievement by intermediate (Year 7 and 8) students as well as revealing concerns with the science programme level in general. The TIMSS data identified a wide variety of complex factors that could inhibit effective science programme implementation in New Zealand schools. Although many of these forces included external, system related components, it was inferred that the chief influencing factors related to teachers' knowledge, confidence and skill in implementing the science curriculum at classroom level.

Immediately following the release of TIMSS a ministerial taskforce for mathematics and science education identified teacher confidence and competence as major factors inhibiting effective programme delivery (Walker & Chamberlain, 1999). Similarly, a study by Lewthwaite (1999) found that "approximately half" (p.15) of primary and intermediate teachers consider that confidence was a problem in teaching science.

Along with issues of confidence, the TIMSS Revisited (TIMSS-R) asserted that effective science teaching depends on teachers having the subject matter knowledge and the professional training to maximise students' learning of the subject (Ministry of Education, 2001). No link between teacher knowledge and confidence was investigated.

earth science education has received very little systematic research either internationally, or within a New Zealand context. Vallender (1997) speculates that this reflects the status of earth sciences in school curricula or that very few geoscientists are involved in science education reform.

Much of the information regarding earth science education in New Zealand comes from research on science education in general. These sources, along with the few pieces of work on earth science itself, reveal that earth science is generally held in low regard when compared to the more traditional science disciplines (Vallender, 1997). The domain of earth science is generally misinterpreted (*ibid.*) and that the same problems of poor teacher confidence and knowledge exist in earth science as they do in other science disciplines. In some conceptual areas, such as the geological history of New Zealand or astronomy, poor teacher confidence and knowledge are even more of an issue than traditional 'hard' topics such as energy or electricity (Lewthwaite, 1999).

Rationale for the Study

The results of numerous research efforts have shown that teachers' professional knowledge and confidence are major issues in science education. However addressing these issues is not straightforward. In the wake of TIMMS, the Ministry of Education embarked on an ambitious programme to improve the implementation of *Science in the New Zealand Curriculum*. These efforts consisted largely of in-service professional development programmes and the development of teacher resource materials. These efforts were commendable, though for the most part, more effective rhetorically than professionally Lewthwaite (2001).

This study attempts to address the problems identified in studies such as TIMMS. It is by no means the intent of this study to solve such complex issues, but rather to identify the nature of the problems at hand so that they can then be more effectively addressed in the future.

The purpose of this study is to ascertain the nature of any relationship between the various types of knowledge that primary and intermediate teachers possess, and their confidence to teach programmes based in the *Making Sense of Planet Earth and Beyond*. If such a relationship does exist and is meaningful, it may be possible to build teachers' confidence in the teaching of earth science subjects through developing their professional science knowledge. Such development may include a broadening and deepening of earth science subject matter, effective teaching/explanatory strategies, useful learning activities, improving awareness of curricular requirements and resources, or any combination of similar professional knowledge requirements.

Significance of the Study

There is very little research in the areas of earth science in New Zealand schools and relationships between efficacy and knowledge structures. It is hoped that this study will provide valuable seminal data in these areas. Additionally, though it is not the intent of this study, the findings of this investigation may also have applications in other science education disciplines. It is anticipated that the findings of this study will be valuable to the teacher education community. It investigates two major factors in effective science

programme delivery. Any relationships found between these two areas may be of great use to those developing programmes to address these concerns in current and future primary and intermediate teachers.

This study may be significant internationally. The concerns of primary science education in New Zealand are similar internationally (Lewthwaite, 2001). The findings of this study may be of value to educators from other countries that are also attempting to improve the effectiveness of their own earth science programme delivery.

Outline of the Thesis

This Thesis is presented in seven chapters and additional appendices.

Chapter One details the background and reasons for the study. It considers the possible significance of the findings of the study. It outlines that aims, intentions and structure of the investigation and the thesis.

Chapter Two involves a review of the literature in fields relevant to the study. It considers (1) the history, structure and implementation of the New Zealand science curriculum as well as the place and implementation of earth science in New Zealand science education; (2) self-efficacy and its influence of teaching and science teaching and (3) the dimensions and sources of professional science knowledge for teachers.

Chapter Three reviews the methodologies involved in the collection and interpretation of data in the study. It addresses the theoretical framework of the study and explains the authors' reasoning behind the data gathering techniques chosen and considers the methods used to analyse these data.

Chapter Four considers the data gathered in the first phase of data collection, the teacher survey. These data are analysed graphically and statistically using ANOVA and regression analyses. This chapter identifies commonly occurring trends and themes and makes some consideration in light of links with other relevant data and the work of previous researchers.

Chapter Five addresses the analysis of data gathered during the second phase of data collection, the teacher interviews. It considers teachers' responses and identifies commonly occurring themes in the light of results from phase one and existing research.

Chapter Six discusses the major findings of the study in the light of the findings of both phases of data collection and with due consideration to the findings of previous workers.

Chapter Seven reviews the processes involved in the execution of the study, considers the study's major findings and their significance. It discusses the implications of the limitations in the study methodology and implementation and makes recommendations for further research.

The appendices contain additional material that is pertinent to the study. It includes the survey used in phase one and the interview framework used in phase two. A thorough bibliography of the reference material used in the study is included.